National Aeronautics and Space Administration

NASA Office of the Chief Technologist and Space Technology Program FY 2013

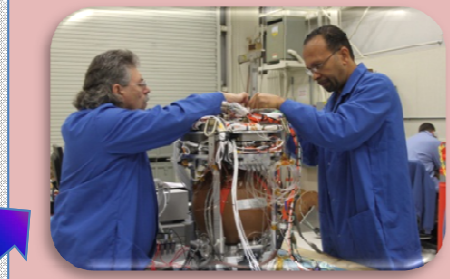
NASA Advisory Council

James Reuther
July 24, 2012

Office of the Chief Technologist

Integrates Technology Investment Across the Agency

Serves as Advisor to Administration



Direct Technology Management and Budget Authority for the Space Technology Program

Office of the Chief Technologist

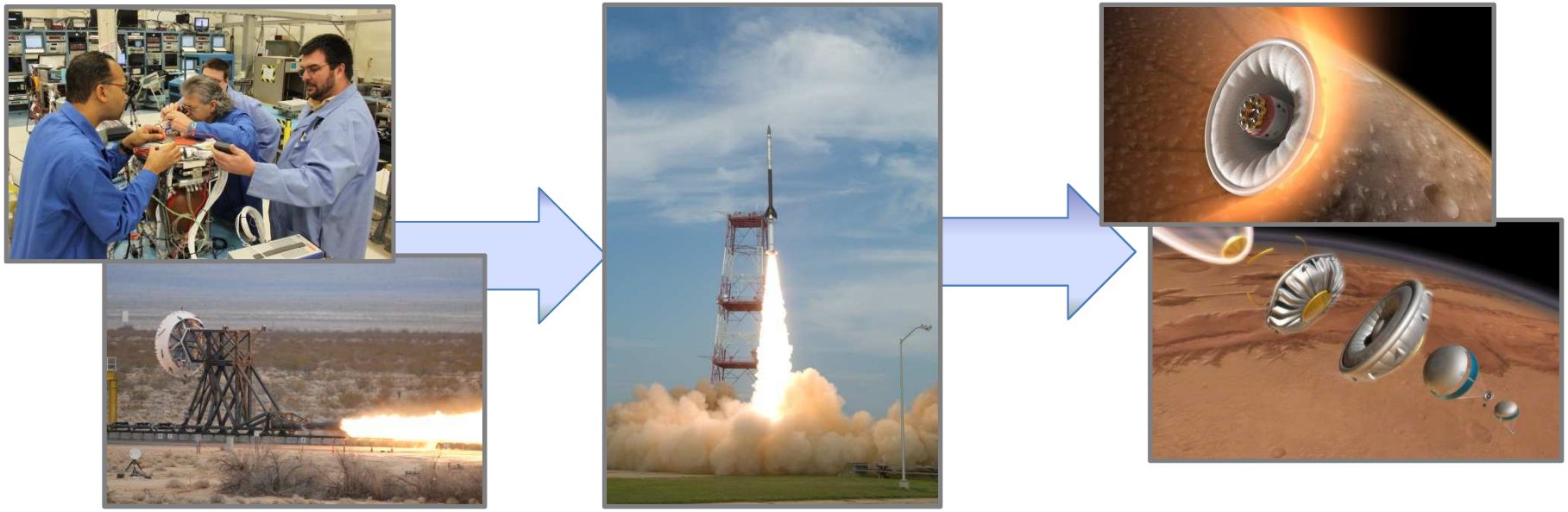
Leads Tech Transfer, Partnerships and Commercialization Activities Across the Agency

Advocates Externally NASA's R&D Programs

Demonstrates and Communicates Societal Impacts of NASA Technology Investments

Space Technology: Investments in Our Future

- **Enabling Our Future in Space:** By investing in high payoff, disruptive technology that industry cannot tackle today, *Space Technology* matures the technology required for NASA's future missions in science and exploration while proving the capabilities and lowering the cost for other government agencies and commercial space activities.
- **NASA at the Cutting Edge:** Pushing the boundaries of aerospace technology and seizing opportunities, *Space Technology* allows NASA and our Nation to remain at the cutting edge.



Space Technology Programs

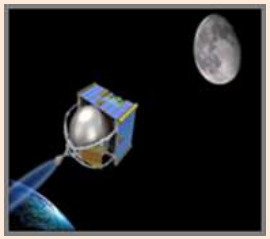
Transformative & Crosscutting Technology Breakthroughs

Pioneering Concepts/ Developing Innovation Community

Creating Markets & Growing Innovation Economy

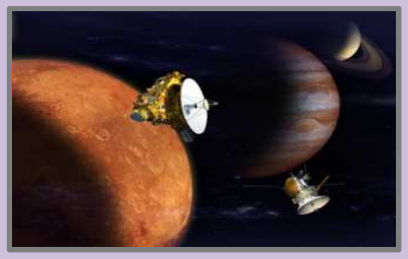
Game Changing Development Program

Technology Demonstration Missions Program



Small Spacecraft Technologies Program

Space Technology Research Grant Program

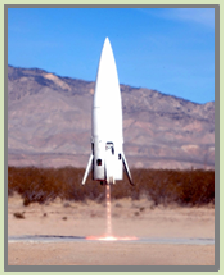


NASA Innovative Advanced Concepts (NIAC) Program

Center Innovation Fund Program

Centennial Challenges Prize Program

Small Business Innovation Research & Small Business Technology Transfer (SBIR/STTR) Program

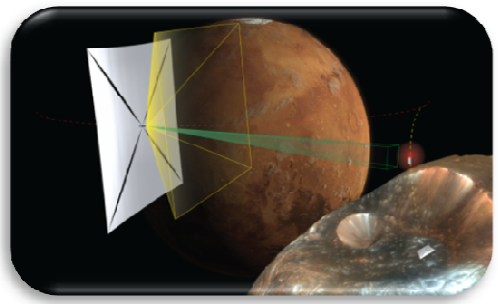


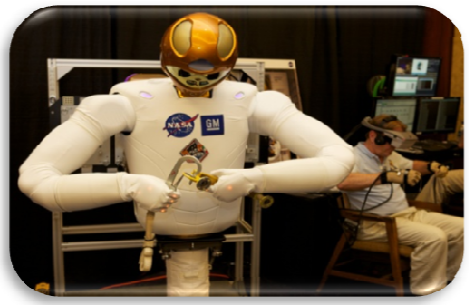
Flight Opportunities Program

Guiding Principles of the Space Technology Program

Space Technology Program

- **Adheres to a Stakeholder Based Investment Strategy:** NASA Strategic Plan, NASA Space Technology Roadmaps / NRC Report and Strategic Space Technology Investment Plan
- **Invests in a Comprehensive Portfolio:** Covers low to high TRL, student fellowships, grants, prize competitions, prototype developments, and technology demonstrations
- **Advances Transformative and Crosscutting Technologies:** Enabling or broadly applicable technologies with direct infusion into future missions
- **Selects Using Merit Based Competition:** Research, innovation and technology maturation open to academia, industry, NASA centers and other government agencies
- **Executes with Structured Projects:** Clear start and end dates, defined budgets and schedules, established milestones, and project authority and accountability.
- **Infuses Rapidly or Fails Fast:** Rapid cadence of technology maturation and infusion, informed risk tolerance to infuse as quickly as possible
- **Positions NASA at the cutting edge of technology:** Results in new inventions, enables new capabilities and creates a pipeline of innovators for National needs





Space Technology FY 2013 President's Budget Request

Budget Authority ($M)	FY 2012 Appropriation	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**573.7**	**699.0**	**699.0**	**699.0**	**699.0**	**699.0**
Partnership Development and Strategic Integration	29.5	29.5	29.5	29.5	29.5	29.5
SBIR/STTR	166.7	173.7	181.9	187.2	195.3	206.0
Crosscutting Space Technology Development	187.7	293.8	272.1	266.6	259.7	247.0
Early Stage Innovation	39.8	59.0	61.0	61.0	61.0	61.0
CSTD Game Changing Technology	61.5	66.7	73.7	69.1	58.4	58.4
CSTD Technology Demonstration Missions	65.3	128.9	103.4	102.5	106.3	93.6
Edison/Franklin Small Satellites	11.2	24.2	19.0	19.0	19.0	19.0
Flight Opportunities	10.0	15.0	15.0	15.0	15.0	15.0
Exploration Technology Development	189.9	202.0	215.5	215.7	214.5	216.5
ETD Game Changing Technology	111.2	104.0	70.5	79.8	85.9	90.9
ETD Technology Demonstration Missions	78.7	98.0	145.0	135.9	128.6	125.6

Space Technology Status

- **Space Technology included in NASA Authorization Act of 2010**
- **FY 2011 Operating Plan funded STP at approximately $350M**
- **FY 2012 Space Technology Program funded at $575M**
- **The Space Technology Program formulated a "Portfolio" with 10 programs:**
  - Combination of new programs and existing programs
  - Combination of directed and new, competitively selected content
  - 400 NASA employees in FY 2011; 900 NASA employees in FY 2012
- **Portfolio Commitment Agreement signed August 2011**
- **FY2011 & FY2012 solicitations released**
- **Over 1000 projects in execution from continued projects & FY11 awards**

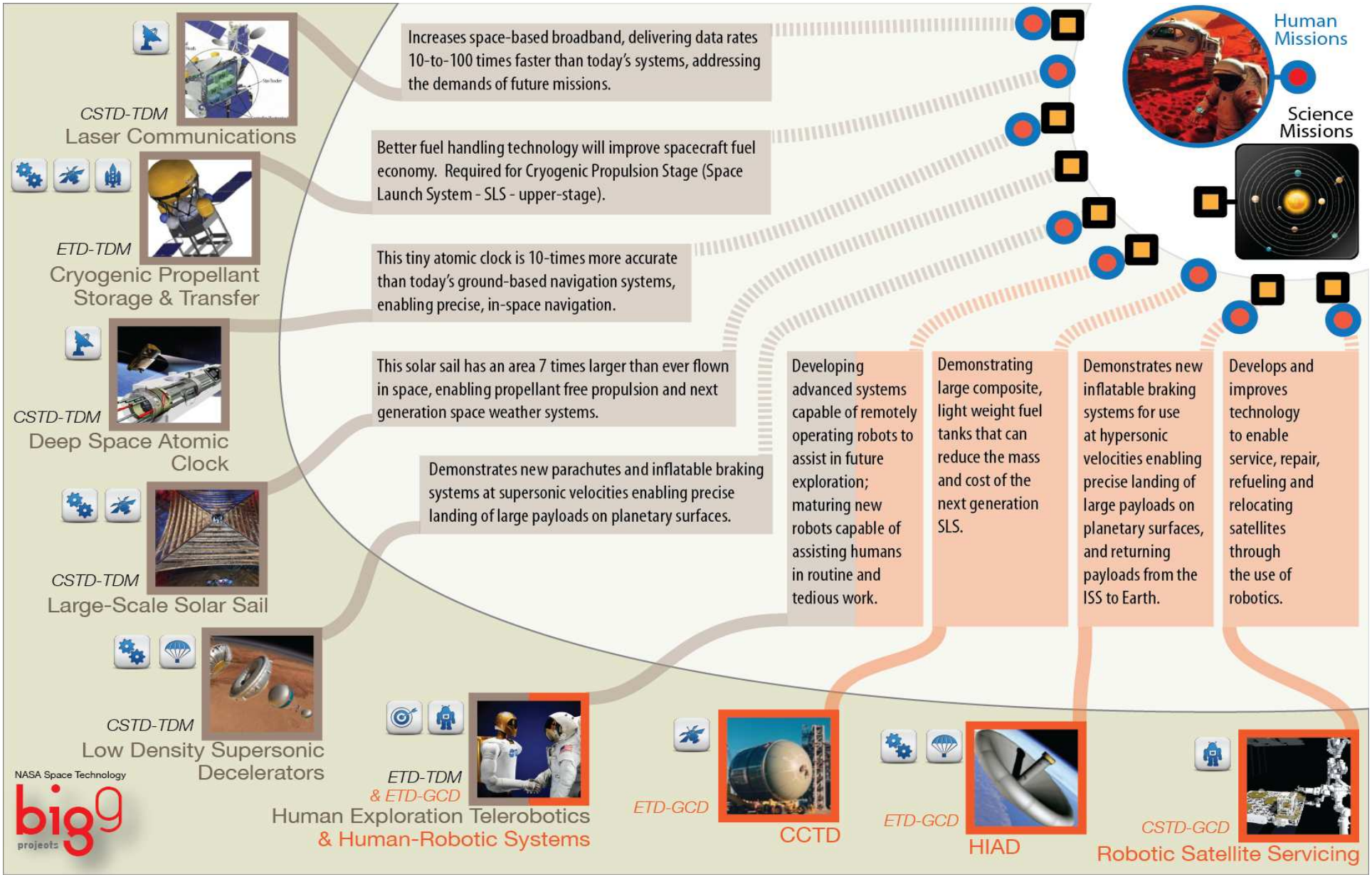
30	NASA Innovative Advanced Concepts (NIAC)
80	Space Technology Research Grants (STRG) - Fellowships
~750	SBIR/STTR
~100	Center Innovation Fund (CIF)
2	Centennial Challenges
1	Small Spacecraft
23	Flight Opportunities (FO)
~30	Game Changing Developments (GCD)
9	Technology Demonstration Missions (TDM)

FY 2012 Solicitation Status

	FY 11 Status	FY 12 Solicitation Date	FY 12 Award Date	FY 12 # of awards
STRG Fellowships	80 awards made – all continuing	Nov 2011	Aug 2012	48
STRG Early Career Faculty	NA	Feb 2011	Sep 2012	~10
STRG Early Stage Innovation	NA	May 2012	Oct 2012	~10
NIAC Phase I	30 awards	Feb 2012	Jul 2012	~20
NIAC Phase II	NA	Mar 2012	Jul 2012	~10
SBIR / STTR Phase I	450 / 45 awards	Jul 2011	Nov 2011	260 / 40
SBIR / STTR Phase II	239 / 27 awards	Jul 2011	Dec 2011	85 / 10
Centennial Challenges	Green aviation prize award	NA	Robotics Challenge Jun 2012	10 teams – no winner
FO Flight Services	7	NA	NA	NA
FO Payloads	16	Jun 2011 / Dec 2011	Oct 2011 / Mar 2012	9 / 24
GCD / FO Payloads	NA	Feb 2012	Jul 2012	14
Small Spacecraft	NA	Feb 2012	Aug 2012	~2-4
GCD Unique & Innovative	1 award	open	open	2 + ~3-4
GCD Solar Array	NA	Apr 2012	Aug 2012	~1-3
TDM Green Propellants	3 awards	Feb 2012	Jul 2012	~1

Red text implies anticipated dates and award numbers

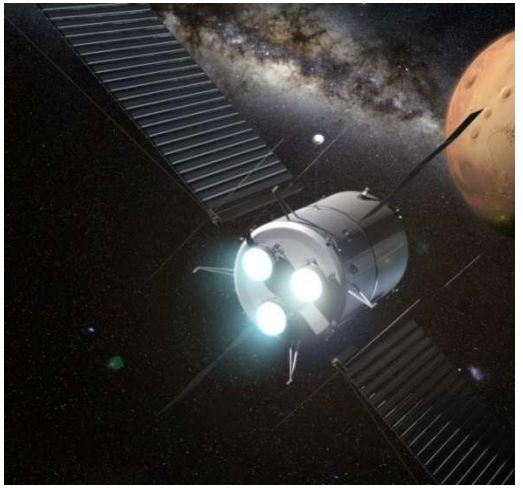
Current (FY2012) Big Nine Programs



FY12 Awards for Solar Array Systems & Green Propellants

Solar Array Systems

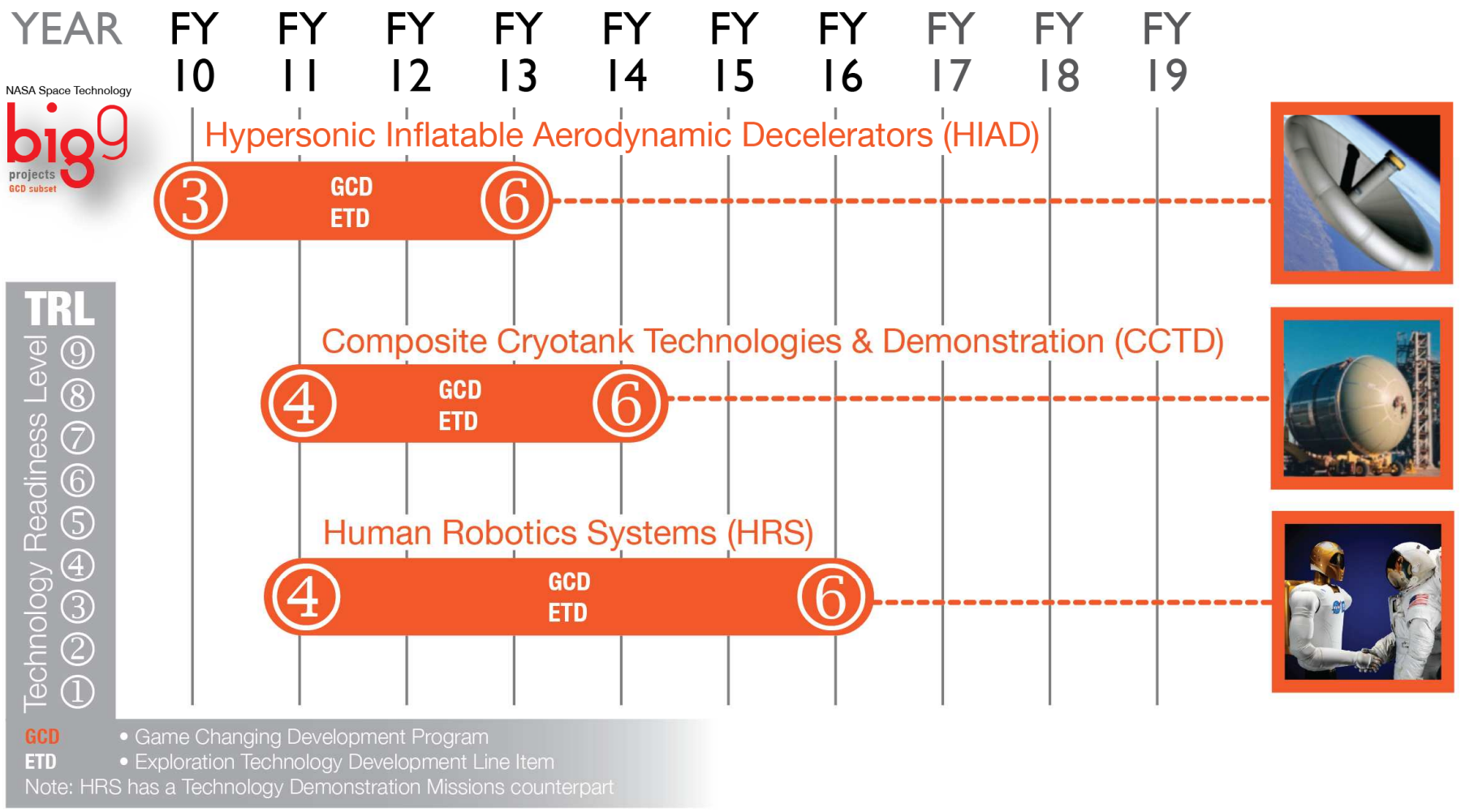
- High Power Solar Electric Propulsion (SEP) is a required architecture element within the human exploration roadmap
- STP will develop critical technologies and demonstrate an integrated SEP system that is extensible to human exploration missions at 300kW
- GCD recently released BAA for ground demonstration of large-scale Solar Array Systems
  - Phase 1 will involve design, development, analysis and ground testing of candidate systems
  - TDM will conduct a follow on Phase 2 development of the Solar Array Systems technologies that concludes with an ISS demo



Green Propellants

- Hydrazine fuel is used extensively for space systems. However, hydrazine is highly corrosive and toxic. Alternatives to hydrazine are at a tipping point and ready for infusion.
  - TDM recently released Broad Agency Announcement for demonstration of Green Propellant Alternatives to Hydrazine
  - Green propellant alternatives to hydrazine a key driver in expanding the capabilities of smaller spacecraft systems

NASA Space Technology Program: GCD's 3 of the Big 9 STP Projects



NASA Space Technology Program
GCD's 3 of the Big 9 STP Projects

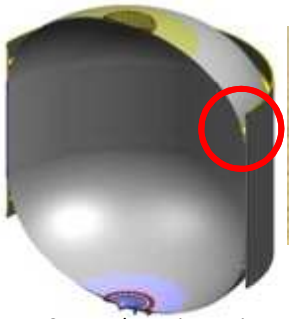
Hypersonic Inflatable Aerodynamic Decelerator (HIAD)

- **IRVE-3:** was shipped to Wallops Flight Facility 6/31; Completed an MRR on (7/13); Followed by a successful STP KDP-E on (7/16); The IRVE-3 successfully launched on 7/23.
- **3-m aeroshell:** completed flexible TPS testing in LCAT facility.
- **HIAD 6-m inflatable structure:** completed testing in the NFAC facility.

IRVE-3

Composite Cryotank Technologies & Demonstration (CCTD)

- Identified Y-Joint insufficient margin of safety;
  Solution: use of softening strip.
- Completed coupon testing, which will feed into additional analyses to validate improved margin of safety for the 5.5 m diameter cryotank y-joint region.



Cryotank Y-Joint region

Softening strip

Human Robotic Systems (HRS)

- **Rover Ballistic Cannon:** assembly was completed successfully.
- **Centaur 2:** Operation over 4 days; long distances (1.5 km); with limited communications (1 Mbps). Integration testing in preparation.
- **Grapple arm:** First prototype with anchoring device for soft regolith on ATHLETE

Ballistic Cannon

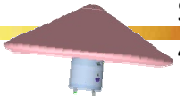
ATHLETE's wheels

IRVE-3 Launch Profile

Updating to as-built mass properties

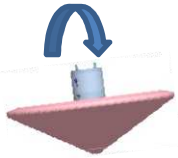
Apogee
366s, 476km

Coast…

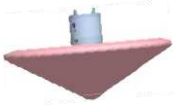


Start Aeroshell Inflation
478s, 423km (110s to 7.5psi)

Eject Nose Cone
132s, 242km



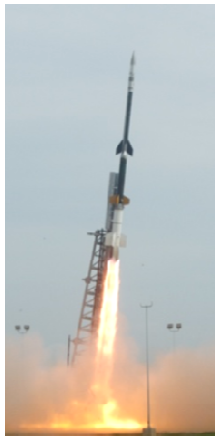
ACS Reorientation
588s, 266km (60s duration)



Actuate CG offset system
648s, 83km (1s duration)

NIACS damps rates
91s to 131s

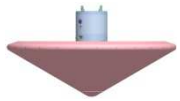
Separate RV & Nose Cone
From Brant & Transition
90s, 149km



Yo-Yo De-Spin, 80s
Brant Burnout, 56.9s
Brant Ignition, 23.0s
Taurus Separation 21.0s
Taurus Burnout, 18.5s
Taurus Ignition, 15.0s
Talos Burnout, 6.4s
Spin Motor Ignition, 0.9s
Leaves Rail, 0.5s
Talos Ignition, 0s

Launch on Black Brant-XI from WFF
940lb payload, El 84deg, Az 155deg

Atmospheric Interface, 25Pa (649s, ~80km)

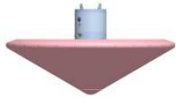


RV Peak Heat Rate 14-17W/cm2
673s, 49km, Mach 7 (peak Mach 10.2)

RV Peak Dynamic Pressure 5035Pa
678s, 41km, 20.8g's

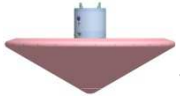
Reentry Experiment Complete at Mach < 0.7 (706s, 37km)

CG Offset Maneuvers



LOS by land radar & TM
12-29km altitude

Vent NIACS and Inflation System Gas



RV splashdown at 30m/s
383km downrange (1227s)

Recovery Attempt

TDM Big 9
MILESTONES/ACCOMPLISHMENTS

Cryogenic Propellant Storage and Transfer (CPST):

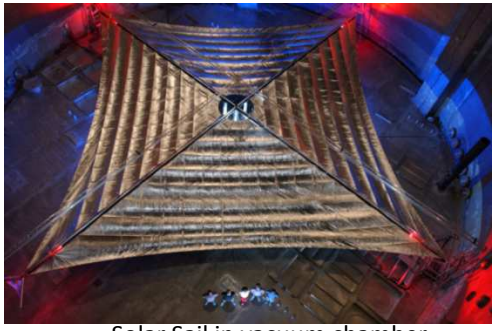
(Project in requirements and mission definition phase)

- Successfully completed Mission Concept Review (MCR)
- Advancing five Cryo technologies from TRL4 to TRL5 with Technology Maturation Activities completing in FY12
- Progressing development of Ground Test Article (GTA) to support integrated system performance assessment in FY13

Solar Sail Demonstration (SSD):

(Project in preliminary design phase)

- Successfully completed Mission Concept Review (MCR)
- Successfully completed preliminary design and for upcoming Preliminary Design Review (PDR)
- Developed and validated sail coating process
- Fabricated short boom sections and compression tested
- Built 94ft long test boom as a packaging demonstration process



Solar Sail in vacuum chamber

Low Density Supersonic Decelerator (LDSD):

(Project in preliminary design phase)

- Completed SIAD Development Verification (SDV) test series at China Lake
- Initiated Parachute Development Verification (PDV) test series at China Lake

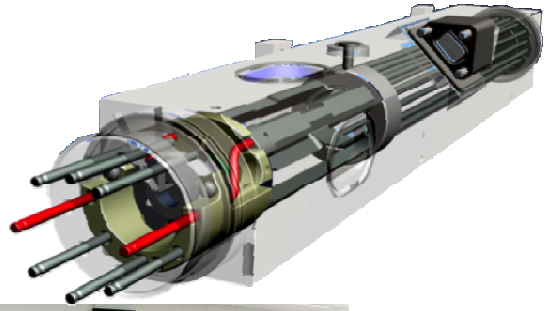
LDSD rocket test sled to demonstrate supersonic inflatables

TDM Big 9
MILESTONES/ACCOMPLISHMENTS

Deep Space Atomic Clock (DSAC):

(Project in Preliminary Design Phase)

- Successfully completed Systems Requirements Review (SRR)
- Completing preliminary design of Physics Package for upcoming sub-system PDR
- Working access to space to initiate needed hosting agreement



Laser Communications Relay Demonstrator (LCRD):

(Project in pre-formulation phase)

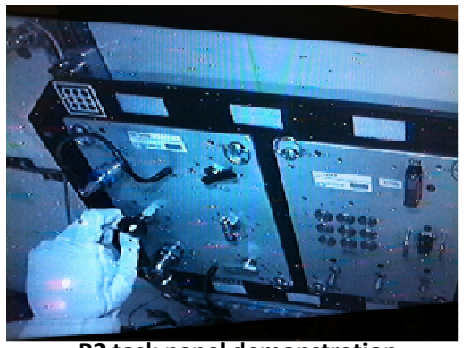
- Completed Flight Terminal hardware development laboratories
- Progressing with partners to establish mission scope

Laser Comm development labs complete

Human Exploration Telerobotics (HET):

(Project in implementation phase)

- Demonstrated ground control of R2 robot manipulating power panel, IVA interface and soft goods on ISS
- Demonstrated ground control of SPHERES performing IVA survey on ISS
- Completing final preparations to demonstrate ISS crew control of surface robot (K-10 Rover at ARC)



R2 task panel demonstration

HET Key Milestones

NASA Space Technology big9 projects

FY11 (ETDD) | **FY12 (TDM)** | **FY13 (TDM)**

Oct Nov Dec | Jan Feb Mar | Apr May Jun | Jul Aug Sept | Oct Nov Dec | Jan Feb Mar | Apr May Jun | Jul Aug Sept | Oct Nov Dec | Jan Feb Mar | Apr May Jun | Jul Aug Sept

- ATP
- Project Status Review
- Project Status Review
- Project Close-Out Review

TECHNOLOGY DEMONSTRATORS

Ground Control Operations

IVA DEXTEROUS MANIPULATOR

- R2 to ISS STS-133
- R2 safety check out
- R2 baseline check out
- **R2 demo**: Ground conducts IVA & small scale dexterous manipulation tasks (**GC 1.1**)
- R2 legs ready for upmass
- **R2 demo**: Ground conducts complex IVA & simulated EVA manipulation tasks (**GC 1.2**)

IVA FREE-FLYER MOBILE SENSOR

- Smartphone to ISS STS-135
- Smartphone camera checkout
- **SPHERES demo**: Ground conducts ISS survey (**GC 2.1**)
- **SPHERES demo**: Ground conducts mobile camera + crew interviews (**GC 2.2**)

Crew Centric Operations

SIMULATED EVA DEXTEROUS MANIPULATOR

- R2 teleop gear to ISS on 45P
- **R2 demo**: Crew conducts simulated EVA repairs with teleop gear (**CC 3.1**)

SIMULATED EVA FREE-FLYER MOBILE SENSOR

- Google NRSAA: Android apps & E/PO
- **SPHERES demo**: Crew conducts simulated EVA inspection using Smartphone controller (**CC 4.1**)

SURFACE TELEROBOTS

- ESA / Meteron: Draft interagency agreement
- **Surface telerobotics ground demo**: K10 rover telescope deployment
- **Surface telerobotics demo**: Crew conducts surface scouting with K10 robot (**CC 5.1**)

Reporting Period: June 2012

Flying, Building, Testing Technologies For Tomorrow


National Aeronautics and
Space Administration
NASA
BACKUP
Office of the Chief Technologist

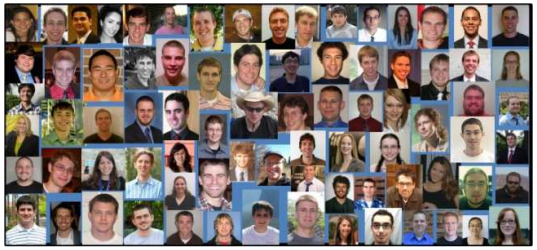
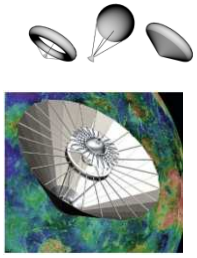
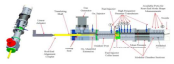
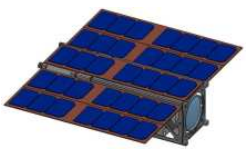
Space Technology Research Grants (STRG) Program Overview

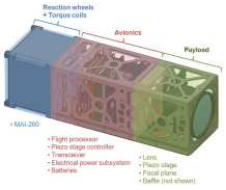
PROGRAM: To accelerate the development of push technologies through innovative efforts with high risk/high payoff and develop the next generation of innovators through:

- **Space Technology Research Opportunities** – Early Stage Innovation **(STRO-ESI)**: technology portfolio of groundbreaking research in advanced space technology
- **NASA Space Technology Research Fellowships (NSTRF):** Competitive selection of U.S Citizen / permanent resident graduate students developing promising technologies in support of future NASA missions and strategic goals

ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):

- STRO-ESI: One year awards with possible renewals; ~$200K/year
- NSTRF: 80 Fellows in inaugural class; NSTRF12 class will be in place ~ August 2012



STRGP Solicitations Summary

Space Technology Research Opportunities

One or more Solicitations Released Annually

- **FY12 Released Solicitations**
  - **STRO- *Early Career Faculty*; $200k/Year, 1-3 years, Expect ~10 Awards**

    Specific High-priority Technologies in these Topic Areas:

    TA05- Communication and Navigation Systems

    TA06- Human Health, Life Support, Habitation Systems

    TA07 -Human Exploration Destination Systems

    TA12- Materials, Structures, Mechanical Systems, and Manufacturing

    (More info at http://tinyurl.com/NASAECF)

  - **STRO- *Early Stage Innovations*; Up to $250k/Year, 1-2 years, Expect ~10 Awards**

    Topic Areas:

    Space Radiation- **Topic 1-** Radiation Protection Systems**; Topic 2-** Radiation Monitoring Technology

    Thermal Management Systems- **Topic 3-** Active Thermal Control of Cryogenic Systems; **Topic 4-** Heat Radiation

    Optical Systems- **Topic 5**- Active Wavefront Control; **Topic 6**- Grazing-Incidence Optical Systems

    (More info at http://tinyurl.com/NASAESI)

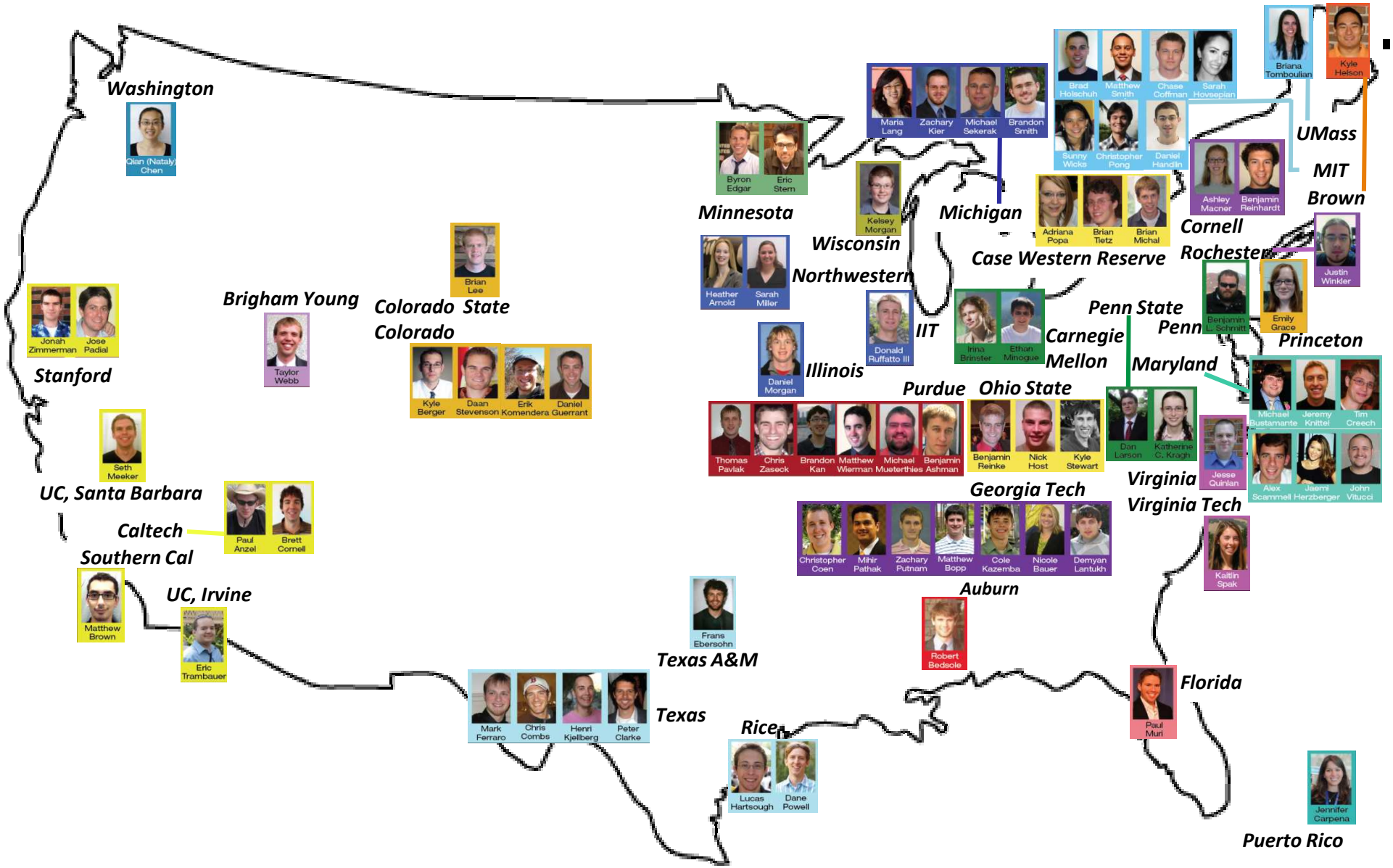
NASA Space Technology Research Fellowships

One Solicitation Released Annually; Up to $66k/Year including faculty support, travel, and NASA Mentor

- **FY11 - NSTRF11 (More info at** http://tinyurl.com/NSTRF11-OCT)
- **FY12 - NSTRF12 (More info at** http://tinyurl.com/NSTRF12-OCT)

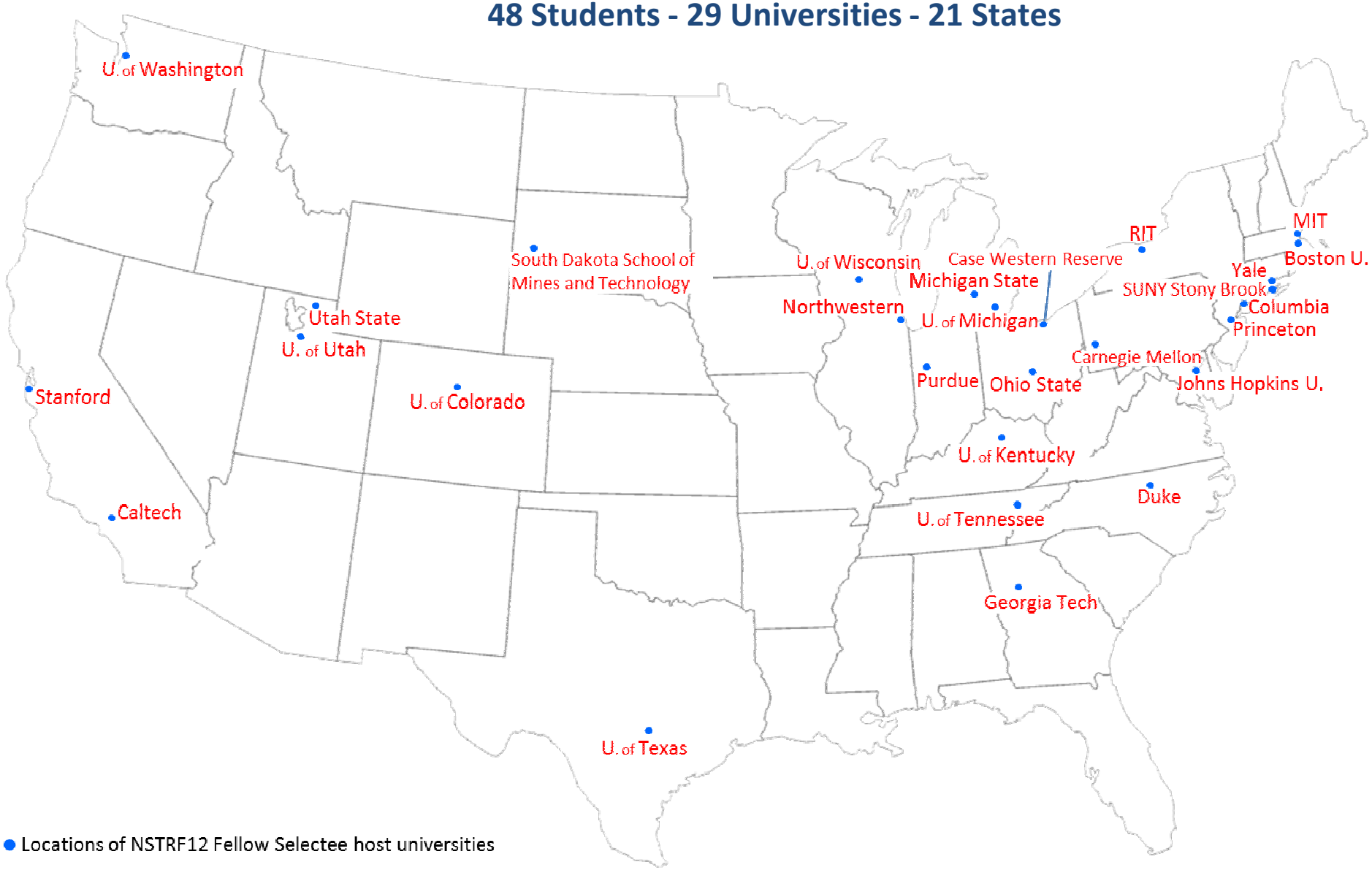
The Inaugural NSTRF Class of 2011

80 Students - 37 Universities - 22 States and U.S. Territories



NSTRF Class of 2012

48 Students - 29 Universities - 21 States



● Locations of NSTRF12 Fellow Selectee host universities

Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR)

- **PROGRAM:** Stimulate technological innovation and support NASA's innovative research to develop technologies for NASA projects while spurring economic growth through commercialization.

- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**
  - Awarded 258 SBIR Phase 1 projects to firms across 37 states and 83 SBIR Phase 2 projects to firms across 26 states
  - Awarded 40 STTR Phase I projects with firms and research institutions across a total of 16 states
  - Selected 10 STTR Phase 2 proposals for negotiation for awards, with firms and research institutions across a total of 9 states. Final awards expected mid-summer 2012.
  - Supported 17 projects with Phase 2E awards in FY 2012
  - Working with Small Business Administration (SBA) to assess implementation of new requirements in recent SBIR/STTR Reauthorization. Expecting Policy Guidelines from SBA in accordance with schedule from reauthorization. SBA anticipates an interim final policy directive by June 30, 2012. NASA's next SBIR/STTR solicitation is expected to be release in late summer 2012.

NASA Innovative Advanced Concepts (NIAC) Program Overview

- **PROGRAM**: **NASA Innovative Advanced Concepts (NIAC)** funds early studies of visionary, long term concepts - aerospace architectures, systems, or missions (not focused technologies). The intended scope is very early concepts: Technology Readiness Level 1-2 or early 3; 10+ years focus
- **ACCOMPLISHMENTS/ MILESTONES (2012-2013):**
  - Jan 9 -- NIAC Phase I NRA released
  - March 27-29 -- NIAC Spring Symposium in Pasadena, CA
  - April 3 -- NIAC Phase II NRA released
  - July -- announce Phase I and II selections
  - Sept 1 -- FY12 studies (Phase I and II) commence
  - Sept 30 -- FY11 final reports due

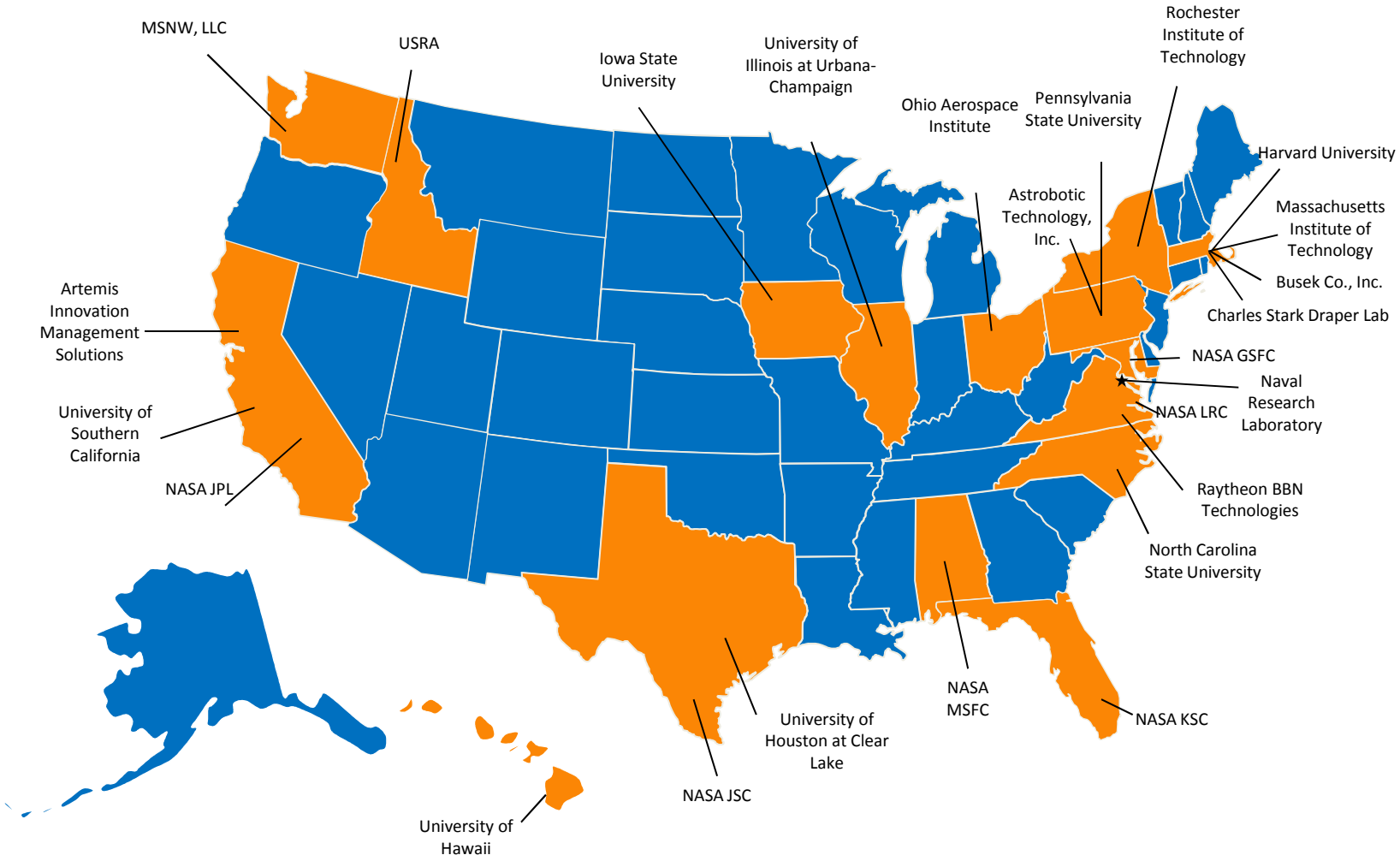






NIAC: Funding Innovation across the Nation

Exploring new concepts to expand aerospace possibilities



Flight Opportunities Program Overview

- **FLIGHT OPPORTUNITIES PROGRAM:** Develops and provides opportunities for space technologies to be demonstrated and validated in relevant environments. Fosters the development of the commercial reusable suborbital transportation industry.

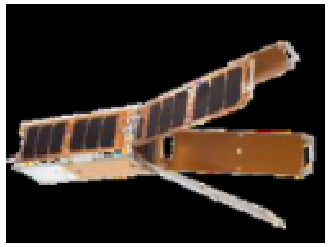
- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**
  - Establishing a pipeline of technology payloads to utilize the anticipated commercial suborbital flight opportunities
  - Selected 49 payloads from three rounds of payload calls (Periodic Call for Payloads)
  - Selected 14 technology development and vehicle enhancement proposals in partnership with Game Changing Development
  - Formed Partnership with New Mexico Space Grants for flying Student Payloads
  - Development of Commercial Vertical Testbed
    - Integration of Draper Labs Technology on Masten Space Systems' Vehicle
    - Successfully completed a free-flight demonstration in Feb 2012

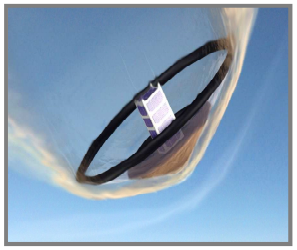
- Planned commercial flight opportunities in 2012 and 2013
  - Four Parabolic Flight Campaigns (May, Aug, Sep, and Oct 2012)
  - Flights on Masten Space Systems, Near Space Corp, UP Aerospace, and Virgin Galactic
  - Qualification flights of Armadillo Aerospace, Whittinghill Aerospace, and XCOR Aerospace

Small Satellite Demonstration Mission Program

EDISON SMALL SATELLITE DEMONSTRATION MISSIONS PROGRAM: Low-cost flight demonstrations of new capabilities and technologies for small spacecraft.

- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**
  - Preparing PhoneSat 1.0 for launch in Summer 2012 demonstrating use of commercial smart phones for onboard satellite navigation, control and communications
  - Began development of EtherSat mission to demonstrate capabilities of satellite swarms for a range of missions projected launch in 2013
  - Released open solicitation for proposed small spacecraft demonstration missions for communications, propulsion and proximity operations
    - Selecting projects for award in August 2012
    - 2 to 3 year projects, up to $15 million per project





Space Technology: Investments in Our Future

- **Through NASA, America Continues to Dream Big:** NASA's future aeronautics, science and exploration missions are grand in scope and bold in stature.
- **Technological leadership is the "Space Race" of the 21st Century:** NASA's *Space Technology* investments will stimulate the economy and build our Nation's global economic competitiveness through the creation of new products and services, new business and industries, and high-quality, sustainable jobs.
- **NASA makes a difference in our lives every day**: Knowledge provided by weather and navigational spacecraft, efficiency improvements in both ground and air transportation, super computers, solar- and wind-generated energy, the cameras found in many of today's cell phones, improved biomedical applications including advanced medical imaging and even more nutritious infant formula, as well as the protective gear that keeps our military, firefighters and police safe, have all benefitted from our nation's investments in aerospace technology.

- **The Nation's investments in *Space Technology* enable NASA to make a difference in the world around us.**